SIR DAVID GILL (1843–1914).[1]

By A. S. Eddington.

By the death of Sir David Gill astronomy has lost one of its ablest and best-known leaders. By his widespread activity, his close association with all the great enterprises of observational astronomy, and by the energy and enthusiasm of his character, he had come to hold an almost unique position in astronomical councils; and the withdrawal of his great motive power leaves a universal sense of loss. By his individual achievements and by his leadership he has exerted an incalculable influence on the progress of all that pertains to precision of observation. It will be our task in this notice to give an outline of his work as an astronomer, but to understand his immense influence it is necessary also to realize the personal character of the man. Those who came in contact with him felt the charm of his personality. In some indefinable way he could inspire others with his enthusiasm and determination. Enjoying a life crowded with activity, surrounded by an unusually wide circle of friends, he was ever ready and eager to encourage the humblest beginner. It was no perfunctory interest that he displayed. He was quick to discern any signs of promise, and no less outspoken in his criticism; but, whether he praised or condemned, few could leave him without the truest admiration and affection for his simple-hearted character.

David Gill was born at Aberdeen on the 12th of June, 1843. His family had long been associated with that city, where his father had an old-established and successful business in clocks and watches of all kinds. In due course he entered the Marischal College and University, Aberdeen. At that time J. Clerk Maxwell was a professor there, and his teaching had a great influence on the young student. Judged by ordinary standards, Maxwell was not a successful lecturer; but there were some students who could catch a part of his meaning as he "thought aloud" at the blackboard and feel the impression of his personality in after-lecture conversation, and these found him an inspiring teacher. Gill was among these, and he became imbued with a zeal for experimental science which soon manifested itself in his setting up a small laboratory in his father's house.

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Up to the age of 20 Gill's scientific interests appear to have had no particular inclination to astronomy, but in 1863 he became desirous of securing an accurate time service at Aberdeen. Encouraged by a visit to Prof. Piazzi Smyth at Edinburgh Observatory, he succeeded in interesting Prof. David Thomson in his efforts. There was at that time an old observatory at King's College, Aberdeen. Together the two men unearthed and set up in adjustment a portable transit instrument which had long been disused, the sidereal clock was overhauled and fitted with contact springs for the electrical control of other clocks, and the observations for time determination now became the chief occupation of Gill's leisure evenings.

It was not long before he began to seek for an instrument which would give him a wider scope for astronomical work. He met with a second-hand silver-on-glass mirror of 12 inches aperture and 10 feet focal length. The task of mounting this equatorially gave him the first opportunity of displaying that skill in instrumental designing for which he afterwards became so famous; and the whole mounting was made from his working drawings. He made the driving clock with his own hands.

Among the chief results obtained with this telescope were some excellent photographs of the moon. At that time Lord Lindsay (son of the Earl of Crawford) was planning to erect an observatory at Dun Echt, 13 miles from Aberdeen. Having seen these photographs, he visited Gill in order to see his instruments and methods of work. The acquaintance thus formed led to Gill's receiving early in 1872 an invitation to take charge of the Dun Echt Observatory that was about to be erected.

At this time Gill was actively at work all day, his father having retired, leaving the business in his hands; it was only his evenings that could be devoted to scientific pursuits. He had married in 1870, and was living in Aberdeen near his little observatory. To accept Lord Crawford's offer meant the giving up of a flourishing business and a heavy pecuniary sacrifice; but by now astronomy was claiming him irresistibly, and he made the choice without hesitation. The business that he now relinquished had never been congenial to him; but the time he had devoted to the clockmaker's art had not been wasted, for it is reasonable to believe that his natural mechanical genius was in no small measure fostered by this early training.

Gill's direction of the Dun Echt Observatory lasted from 1872 to 1876. It was his task to design and install the fine equipment that was rapidly acquired—for him a foretaste of the similar work he was afterwards to carry out at the Cape. But this period of his life is chiefly remembered not for observations made at Dun Echt but for an expedition to the island of Mauritius on the occasion of the transit of Venus, 1874. It was in preparation for the work at

Mauritius that he first began to use the heliometer, an instrument with which his most celebrated researches were afterwards made. The 4-inch heliometer of the Dun Echt Observatory (afterwards purchased for the Cape) was made under Gill's superintendence by Repsold; and whilst it was in the course of construction he took the opportunity to visit Hamburg for the meeting of the Astronomische Gesellschaft in 1873. Besides attending this congress, Gill visited several of the continental observatories, and in this way made the acquaintance of the leading European astronomers, and also obtained an insight into the organization of the large observatories.

The Mauritius expedition introduced him to two of the great problems, which more especially he made his life's work—the determination of the solar parallax and the problems of geodetic measurements. Deferring, for the present, consideration of the scientific results of this expedition and of another expedition to Ascension Island in 1877, we pass on to the next great step in his career.

Early in 1879 David Gill was appointed by the admiralty to be Her Majesty's astronomer at the Cape of Good Hope, in succession to Mr. E. J. Stone. Before sailing for the Cape he made another tour of the European observatories, visiting Paris, Leiden, Groningen, Hamburg, Copenhagen, Helsingfors, and Poulkovo. Perhaps the most important fruit of these visits was his acquaintance with Dr. Auwers and Dr. Elkin, which led to much valuable cooperation between them.

On the 29th of May, 1879, he arrived at Cape Town and took up his duties at the observatory. The only instruments which he found in use were the Airy transit circle, a 7-inch equatorial, and a photoheliograph. The observatory, founded in 1820, had fulfilled a useful duty by the regular work of meridian observation, the early Cape Catalogues being a most valuable source for the positions of the southern stars. Its history had also been marked by one conspicuous achievement—Henderson's detection of the parallax of α Centauri, the first proof that the parallax of a fixed star could amount to a measurable quantity. Whilst the instruments and observations might be open to many criticisms, the work was, for that period, fairly efficient. But the standard of precision was being raised, and Gill's standard was the highest of his time. To his mechanical insight the faulty design and unsatisfactory repair of the old instruments was apparent, and he would not rest until the defects were remedied. He was no believer in the Airy type of transit circle, incapable of reversal, but it was many years before he could obtain an instrument according to his ideals. Meanwhile it was necessary to make the best of the existing telescope. The object glass was deteriorated, the micrometer screws were worn, and the whole instrument was in need

of a thorough overhaul. He at once set to work upon it with his usual energy, and so transformed it that for differential work it left little to be desired. The Airy transit circle performed useful service until 1901, when it was replaced by the new reversible transit circle. It is still used at times for special researches. The 7-inch equatorial was likewise submitted to a thorough overhaul.

The only immediate addition to the equipment was the 4-inch heliometer, which was secured by Gill by private purchase. With this provision he was content to spend the first few years of his directorship, until he should be in a stronger position to press his claims on the treasury. The principal additions made during the subsequent years that he spent at the Cape were the 6-inch Dallmeyer lens used for the photographic Durchmusterung, acquired in 1884; the 7-inch heliometer in 1887, the astrographic refractor erected in 1890, the Victoria telescope (a 24-inch photographic refractor with guiding telescope and spectroscopic equipment) in 1898, and the reversible transit circle in 1901. He was thus for his first researches limited to instruments of very moderate size and cost, and the success with which he afterwards obtained an adequate provision for the observatory was due both to the confidence inspired by his brilliant early work and to his pertinacity in pressing the needs of astronomy.

If from his many and varied services to astronomy we were asked to pick out the one in which he arrived at the most striking and complete success, there is little doubt that the answer would be his determination of the solar parallax. At the time when Gill, by accepting the charge of the Dun Echt Observatory, definitely embarked on an astronomical career a celestial event of the first magnitude was approaching—the transit of Venus of 1874. Great expectations were entertained that this would afford an improved determination of the solar parallax, a fundamental constant which was at that time involved in unsatisfactory uncertainty. Preparations were made by the leading observatories and astronomical societies on an unprecedentedly lavish scale, and expeditions were dispatched to different parts of the world. Lord Lindsay was cooperating in the work, and the Dun Echt expedition took up a station at Mauritius. Gill had already formed the opinion (which he afterwards conspicuously advocated) that there were other and better methods of finding the sun's parallax involving far less expense. He believed that the observations of the transit were of such a nature that the results would be inaccurate and capable of more than one interpretation, for too much depended on the arbitrary judgment of those who had to discuss the observations. He determined, therefore, to use the opportunity of the expedition to make trial of another method, namely, morning and evening observations of the minor planet

Juno, which was then favorably situated. He considered that a single observer could by heliometer observations of a minor planet obtain results comparable in accuracy with those derived from all the transit of Venus observations together. Unfortunately, the heliometer was delayed in arrival at Mauritius, and the first half of the opposition of Juno was lost. Observations in the latter half were secured on 12 evenings and 11 mornings, but the parallax factor was then small. The result, $8''.77 \pm 0''.041$, though disappointing owing to the causes mentioned, gave a clear indication of the value of the method, and this pioneer effort served its purpose as a preliminary to a more ambitious attempt. From that time onwards Gill had a strong conviction of the value of the heliometer for work of the highest refinement, and he acquired his remarkable skill in using it. The transit of Venus was observed by the party, but Gill appears to have formed so low an opinion of the trustworthiness of the measures that he took little interest in their subsequent use.

In 1877 an exceptionally favorable approach of Mars to the earth offered a good opportunity for a renewed attack on the problem of the solar parallax. Gill, who had resigned his position at Dun Echt, began to prepare for an expedition to Ascension Island for this purpose. He fully expected that Mars would, owing to its large disk, prove to be a less satisfactory subject for heliometer observation than a minor planet, which is practically indistinguishable in appearance from the comparison stars; but the parallax factor was so much more favorable than for any minor planet then known that the opportunity was not to be missed. His anticipations proved correct. The value of the solar parallax now found showed a great improvement on any previous determination. The result, $8''.78$, with a probable error of $\pm 0''.012$, marks a new stage of advance. But Gill by this work became more than ever convinced that the definitive determination of the constant must rest on minor planets.

For his third and final attempt, in 1888–9, the minor planets Iris, Victoria, and Sappho were chosen. Instead of measuring the diurnal parallax, he proceeded this time by the combination of observations made at widely separated stations. This involved a great scheme of cooperation in which many observatories and individuals took some part. The actual heliometer measures of the planets were made mainly by Gill and Finlay at the Cape, by Elkin and Hall at Yale, and by Peter at Leipzig. Of the many other cooperators Dr. Auwers in particular took a large and important share in the work. Accurate places of the comparison stars were needed, and meridian observations of these were made at a large number of places. In the case of Victoria this was supplemented by a heliometer triangulation in order to avoid the various systematic errors that affect meridian observations. The whole discussion, which forms two

large volumes (vi and vii) of the Cape Annals, is a remarkable record of a thorough and laborious undertaking. It was particularly the kind of investigation to bring out the characteristic qualities of Gill's genius. To plan the work required that perfect understanding of instruments and observations in which he was unrivaled; and to carry it through in its completeness required a dogged persistence which overcame all obstacles, an enthusiasm which shirked nothing, and a power of leadership which inspired all his helpers. There have been other great and successful cooperative schemes since then, but we miss in them the unity of execution which the immense driving force of Gill's leadership supplied.

The final result gave for the solar parallax $8''.804 \pm 0''.0046$, and in due course this value was adopted (as $8''.80$) in the Ephemerides. In so far as a single investigation can be held to settle so important a constant, the solar parallax was now known with all the accuracy required for the calculations in which it plays a part. Subsequent researches have all tended to confirm Gill's value; the discordant results found by other methods are disappearing, whilst the superiority of the minor planet method has become more and more manifest. In the Eros campaign of 1900–1901 the Cape Observatory took no share, owing to the northern declination of the planet, but Gill followed the investigation with keen interest and took part in the arrangement of the work. The results from Eros, whilst diminishing the range of uncertainty, so far as accidental errors are concerned, have not appreciably altered the value. Shortly before leaving the Cape, Gill initiated a determination of the same constant by means of spectroscopic observations, the line-of-sight velocity of the earth relative to a star being measured at opposite seasons, so that the earth's orbital velocity is found. These observations are now yielding excellent results.

We have seen that his measurements during the observations of Juno at Mauritius convinced Gill of the value of the heliometer as an instrument of research. In his hands it was capable of remarkable accuracy. The instrument is peculiarly difficult to use, and the number of those who observe with it has always been few. At the time when the 4-inch instrument was constructed for him the heliometer was usually regarded in England as an exercise for the textbook or the examination question. Even now that its possibilities have been demonstrated it has not been taken up widely. At the present day it is natural to prefer photographic methods, which give equal or perhaps slightly superior accuracy, whilst making far less demands on the observer. Perhaps, too, the prospect for future progress and development is more obvious in the case of photographic than of heliometer observations. Certainly Gill's success with the heliometer never blinded him to the advantages

of the long-focus refractor, and he fully shared the modern tendency to depend more and more on photography. But there is one advantage of the heliometer over the photographic refractor, both for solar and stellar parallaxes, on which Gill strongly insisted—the heliometer measures are independent of the color of the object under observation. He maintained, and confirmed by experimental observations, that the skilled observer in making coincidences of the images matches the colors and not the most intense points of the minute spectrum caused by atmospheric dispersion. This is a refinement obviously impossible in photography, and, for example, it is well known that the doubtful effect of atmospheric dispersion leaves a little uncertainty in the solar parallax deduced from the photographic observations of Eros.

So early as 1872 Gill had begun to plan a series of determinations of stellar parallax with a micrometer attached to his reflector—an investigation which was interrupted by his removal to Dun Echt. On his appointment to the Cape he began to apply his 4-inch heliometer to this work. In this he was joined by Elkin, as a volunteer observer, and they set to work on a program of 9 stars, including Sirius, Canopus, α and β Centauri, with some stars of exceptionally large proper motion. The most important outcome of this work was the parallax of α Centauri, $0''.75$, with a probable error of only a hundredth of a second of arc. The desirability of a larger instrument with some alterations of design soon became apparent, and in 1887 a 7-inch heliometer was constructed at a cost of £2,200. With this, Gill and Finlay, and afterwards De Sitter, measured 17 stars, including 12 of the brightest in the southern sky, in most cases with a probable error as low as $\pm 0''.01$. These results were of great interest, establishing the remoteness and intense luminosity of some of the brightest stars, such as Canopus and Rigel. Whenever they have been put to the test Gill's values have always been confirmed. Spurious parallaxes are a great bane in stellar investigation, and, at least until recently, few observers have escaped an occasional bad error; but Gill's parallaxes can always be relied on. His general accuracy has been equaled, perhaps a little surpassed, by some modern photographic determinations; but when we compare the sizes of the instruments—the 40-inch telescope at Yerkes or the 26-inch at Greenwich with his 7-inch heliometer—we must marvel at the precision he could obtain. The following table (given by him) will show the comparative accuracy of his work. It gives the probable error of the measured position of a parallax star:

Cambridge refractor (19.3 feet focus), 4 exposures	$\pm 0''.048$
Yerkes refractor (63 feet focus), 3 exposures	± 0 .026
Heliometer, one complete observation, i. e., 16 pointings	± 0 .036

Another application of the heliometer was made in his determination of the elements of Jupiter's satellites and of the mass of Jupiter. The longitudes of the satellites can be found very accurately from the usual observations of eclipses, but the latitudes are more difficult to derive. Heliometer measures had been made before by Bessel and others, but in all cases the satellite had been referred to the limb or center of the disk. Gill's method was to measure the distances and position angles of the satellites relative to one another; for, as he had found in his observations of Mars, the best results are only possible when the objects to be measured have no sensible disks. The observations were carried out in 1891. On each night the measures were reduced to a constant scale by referring them to the distance between two standard stars. The absolute distance between the standards was determined by a lengthy comparison with the distances of stars employed in the Victoria triangulation, whose definitive coordinates had been found with an accuracy quite exceptional. These observations were the beginning of a very thorough investigation of the whole problem; but the further observations and the discussion of the results were placed by Gill in the hands of younger men, who could give a more undivided attention to the problem. The nature of the investigation required a repetition of the observations at a subsequent date. This was made by the late Bryan Cookson at the Cape in 1901–2. Photographic observations were made concurrently in 1891 and 1902, and again in 1903–4. The whole material thus collected formed an exceedingly valuable source for improving the accuracy of our knowledge of Jupiter's system. The detailed discussion was taken up by De Sitter at Gill's suggestion; he reduced Gill's own observations during a visit to the Cape (1897–99), and worked out the elements and masses derivable from the whole work. It is evident that Gill attached the greatest importance to this work, and, though the later stages were in the charge of other workers, he followed its progress to the minutest detail. His stimulating influence carried it to a successful conclusion, if conclusion it can be called, for in his summary of the work in the History of the Cape Observatory he urges the need for an extended program of future work, and appeals to astronomers to carry it out. His last scientific effort, on the day the fatal illness began, was to write an introduction to De Sitter's discussion.

Gill's detection of the existence of magnitude equation in observations of right ascension with the meridian circle was an incidental result of his heliometer observations at Ascension. This definitive discovery of a systematic personality, by which faint stars are regularly observed too late relatively to bright stars, has been of fundamental importance in meridian work. He took great interest in the problem

of eliminating this peculiarly difficult source of error by screens and other methods, and it was a source of great satisfaction to him that the traveling-wire micrometer seems to have successfully accomplished this object.

Reference has already been made to Gill's early photographs of the moon. These were, of course, not by any means the first lunar photographs, but in 1882 Gill made a notable advance in celestial photography by successfully photographing the great comet of that year. Several pictures of this comet had already been obtained, with fixed camera, and the knowledge thus obtained that the light was sufficiently intense encouraged Gill to attempt to obtain images of greater scientific value by guiding the camera in the modern way. He was assisted by Mr. Allis, a local photographer, from whom he borrowed a doublet of 2½ inches aperture and 11 inches focal length. He mounted this doublet on the 6-inch equatorial, which he used as guiding telescope. Excellent representations of the comet were obtained with exposures of from 30 minutes upwards; but, a fact of still greater importance, it was found that, notwithstanding the insignificant size of the apparatus, a great many stars were shown whose images were well defined over a large field. This suggested the practicability of using similar but more powerful instruments for mapping the sky and for other astronomical purposes to which photography is now applied.

We now know how this result has revolutionized the methods of observational work. Gill led the way in turning the new possibilities to a practical account. The immediate outcome was the Cape Photographic Durchmusterung, started in 1885. The survey covers the region of the sky from the South Pole to Dec. – 18°, and is complete so far as photographic magnitude $9^{m}.2$ (on the C.P.D. scale). A rapid rectilinear Dallmeyer lens of 6 inches aperture and 54 inches focal length was used for the photography. The work was completed in 1890. Very soon after the start Prof. Kapteyn's offer was received to devote himself for some years to the arduous labor of the measurement and reduction of the plates, a work for which the Cape Observatory was unable to provide. This is a further instance of Gill's success in attracting for his helpers the men best capable of carrying out the work desired. The association of Gill and Kapteyn, which began now, has proved a most powerful influence in the advance of stellar investigation, and, to quote Gill's own words, "probably the most valuable result of the C.P.D. to science is the fact that it first directed Kapteyn's mind to the study of the problems of cosmical astronomy and thus led him to the brilliant researches and discoveries with which his name is now and ever will be associated."

We can only mention briefly the other photographic work with which Gill was associated. When the history of the inception of the

International Astrographic Chart and Catalogue comes to be written it will probably be found that much was due to Gill's initiative. It may be difficult to trace whence the first suggestion arose, but at least we know that he was in its councils from the very beginning and gave his whole-hearted support to the great enterprise. His measuring machine for photographic plates, designed by him and constructed by Repsold, has been very generally copied in its main features. Another work of great value which owes much to his counsel and assistance is the chart of the sky made by the late J. Franklin-Adams. Mr. Franklin-Adams, an enthusiastic amateur, who had only recently applied himself to astronomy, came to the Cape at an early stage of the work to photograph the Southern Hemisphere. It needs little imagination to realize how Gill, by his experienced advice and his insistence on a high standard of quality, helped to make of this the valuable work that it became.

In 1897 the necessary expenditure for a new reversible transit circle at the Cape was at length sanctioned. Since his first appointment Gill had lost no opportunity of urging the need for an instrument which should be free from the defects which were obvious in the old design. For the determination of fundamental right ascensions and declinations the chief requirements are an extreme stability of the instrument, means of eliminating or determining the flexures of the various parts, and of guarding against the effects of temperature changes both in the instrument and in the surrounding air. The problem of equalizing the distribution of temperature was most carefully thought out. The piers were made hollow, covered externally with nonconducting material, and filled with water. The telescope tube was surrounded by a double envelope of copper to minimize the effects of local heating, and the graduated circles were similarly protected by copper disks. Of special interest was Gill's method of obtaining fixed meridian marks for maintaining the azimuth of the transit circle. Four deep pits, reaching down to the unweathered rock, were constructed underneath the long-focus collimating lenses and the marks respectively, and a simple method was devised by which the apparatus above ground could be readily set in a definite position with respect to the vertical collimating lines of object glasses fixed in the rock below. So perfect is the stability of these marks that it has been found possible to measure the movement of the North Pole over the earth's surface by the apparent change of azimuth. It is certain that the device will be widely imitated in future.

On his appointment as H. M. astronomer, in 1879, Gill began to consider the question of a geodetic survey of South Africa. His previous experience of such work had been obtained on the occasion of his visit to Mauritius. In connection with the Transit of Venus expeditions of 1874, numerous longitude determinations were made

by the various parties of observers; and, indeed, these geodetic results proved to be the most important outcome of the whole work. Gill's share was a chain of telegraphic longitudes connecting Berlin with Malta, Alexandria, Suez, and Aden. Before returning home he proceeded to Egypt, in response to an invitation from Gen. Stone, chief of the military staff of the Khedive, in order to measure a base line for the proposed survey of the country. This work made slow progress at first, as Gill had no trained assistance on which he could rely; but in the end, with the help of Prof. Watson, he carried it through satisfactorily. No permanent outcome of this work has survived, for the defining marks of the base line were afterwards destroyed by Arabs.

It would serve little purpose here to enter into the details of the work which Gill succeeded in accomplishing in South Africa. Besides the more practical uses of an accurate survey, Gill kept ever in view the object of the ultimate measurement of the great arc of the meridian of 105° from the North Cape to Cape Agulhas—the longest measurable arc of the meridian in the world. Colonial and foreign Governments, the Chartered Company, and the scientific societies were all in turn pressed and persuaded. Difficulties of funds, of personnel, of war, interposed obstacles; but there was no resisting Gill. His indomitable persistence always won in the end. Worried ministers would ultimately come to terms with their genial persecutor. Still active in this great cause after retirement from the Cape, he had the satisfaction of getting the last link of the South African chain filled in. The great measured arc along the meridian of 30° E. now extends from Cape Agulhas to within a short distance of Lake Tanganyika, near the boundary of British territory, a length of 24°, at which point it awaits the other chain of triangulation that will some day be pushed down from Egypt.

We have now passed in review the most important of Gill's scientific investigations. To these may be added some miscellaneous contributions, of which we can not here give any detail. A triangulation by heliometer of the southern circumpolar stars was made under his direction in 1897–1900, but he was not very satisfied with the consistency of the observations. A series of meridian observations of the lunar crater Mösting A, organized by him jointly with Sir William Christie at Greenwich, led to a good determination of the lunar parallax and figure of the earth. The arrangements for a catalogue of zodiacal stars were placed in his hands by the International Astrographic Congress.

In October, 1906, Sir David Gill left the Cape. Owing to ill health he had anticipated by rather more than a year the date of compulsory retirement. But there were no signs of failing vigor when he returned to England; on the contrary, he plunged into a

strenuous life of scientific activity in London. He became president and afterwards foreign secretary of the Royal Astronomical Society, president of the British Association at Leicester, and on the councils of the Royal and Royal Geographical Societies as président d'honneur of the committee of the astrographic chart, and in numerous other duties he was a center of energy and initiative. For several years he worked at his History and Description of the Cape Observatory, published in 1913. Amid our sorrow at his death, when still in the full vigor of scientific activity, there is cause for thankfulness that he was spared to complete and to see the reception of this retrospect of the work to which he had devoted his life.

To this record of strenuous work in the cause of science must be added some allusion to the other side of his life. There was an ideal background to his public life in the quiet home, always characteristically Scotch wherever he lived. In Lady Gill he found a sympathizer in all his sacrifices and devotion to astronomy. She did not become an astronomer, but she shared all his desires, and it was ever her care to aid him to fulfill his great calling. She was of Scotch birth, like himself, and their home was bright with an indescribable spirit of open-heartedness which seemed to come from his loved Highlands.

In December, 1913, he was seized with double pneumonia, and from the first the gravity of the illness was realized. His magnificent constitution carried him bravely through a long fight with the disease, but heart failure supervened, and on the morning of January 24 he died peacefully.

There is no need to enumerate the honors conferred on him by the British, French, and German Governments, and by numerous academies and universities. Official recognition was generously bestowed; even richer was the tribute of admiration and affection of his world-wide circle of friends.